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# EFFECT OF CHARACTERIZATION PROPERTIES ON COMPRESSIVE STRENGTH OF CONCRETE CONTAINING QUARRY DUST AND WASTE PLASTIC AS FINE AGGREGATE

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## ABSTRACT

*The scope of this study is to enhance the industry understanding of the sustainable utilization of quarry dust, and to identify any gaps in current knowledge. The term sustainable utilization implies the use of quarry dust to their full potential to meet the needs of the present, while at the same time conserving natural resources and finding ways to minimize the environmental impacts associated both with quarry fines production and use. Concrete mixes were casted using ordinary river sand and compared with 25%,50%,75%, 100% replacement with quarry dust in combination with waste plastic in fabriform. . The addition of quarry dust along with waste plastic significantly improved the concrete matrix properties in terms of strength. Regression analysis and validation of the models developed was done to co-relate the results of compressive strength for 7, 14, 28, 90 days .The addition of fine quarry dust with ldpe as waste plastic in concrete resulted in improved matrix densification compared to conventional concrete. Matrix densification has been studied qualitatively through petro graphical examination using digital optical microscopy. The structure was evaluated using XRD and SEM in quarry dust and ldpe composites.*

**Key words:** Natural Sand; Quarry Dust; Waste Plastic, XRD, SEM Analysis

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# 1. INTRODUCTION

In the recent past good attempts have been made for the successful utilization of various industrial by products (such as fly ash, silica fume, rice husk ash, foundry waste) to save environmental pollution. In addition to this, an alternative source for the potential replacement of natural aggregates in concrete has gained good attention. As a result reasonable studies have been conducted to find the suitability of quarry dust in conventional concrete. Recycled concrete aggregate, fly ash, blast furnace slag, as well as several types of manufactured aggregates have been studied by many researchers, Zain et al. (2000); Neville (2002); Gambhir (1995). Galetakis and Raka (2004) studied the influence of varying replacement proportion of sand with quarry dust (20, 30 and 40%) on the properties of concrete in both fresh and hardened state (Nevillie, 2002). Saifuddin et al. (2001) investigated the influence of partial replacement of sand with quarry dust and cement with mineral admixtures on the compressive strength of concrete Gambhir (1995), whereas Celik and Marar (1996) investigated the influence of partial replacement of fine aggregate with crushed stone dust at varying percentages in the properties of fresh and hardened concrete. The present study is intended to study the effects of quarry dust addition in conventional concrete and to assess the rate of compressive strength development for different quarry dust to coarse aggregate ratio, Goble (1999), De Larrard and Belloc (1997) reported that the compressive, flexural strength and durability of concrete made of quarry rock dust were nearly 10% more than those of conventional concrete. It was reported that there is a significant increase in the compressive strength, tensile strength, and modulus of rupture for M20 and M30 grade concrete mixes with 20% and 40% replacement of natural sand with stone dust. The workability of the concrete mixes decreased with an increase in the percentage of stone dust. With the fact that concrete contains numerous flaws and micro cracks the use of waste plastics in present study has been incorporated. Ismail, Enas. AL-Hashmi (2007) concluded that the rapid propagation of micro cracks under an applied load is considered responsible for the low tensile strength of concrete. It is reasonable to assume that the tensile strength as well as the flexural strength of concrete can be substantially increased by introducing closely spaced fibers. These fibers would arrest the propagation of micro cracks, thus delaying the onset of tensile cracks and increasing the tensile strength of the material. It can been seen that tensile strength for LDPE/nanoclaycomposite is increasing at the blend composition of clay 2.5 phr and clay 5.0 phr and decreasing at the blend composition of clay 7.5 phr and 10.0 phr. This is because the good dispersion of nanoclay is achieving with the LDPE that lead to the higher tensile strength. According to Liang et al. (2005) this leads to high aspect ratio and possesses a higher stress bearing capability and efficiency. Bahoria , Parbat, Nagarnaik (2013), (2014) revealed that the optimum modifier content of waste plastic as 6% the strength was found to be comparable with the conventional concrete. From the test results it was observed that the compressive strength value of the concrete mix increased with the addition of quarry dust and waste plastic fibers as modifier The compressive strength value increases up to 50% replacement of natural sand with 2 to 6% introduction of waste plastics and when further increased to 8% it decreases but increases with the age of curing.

## 2. RESEARCH SIGNIFICANCE

The main objective of the present work was to systematically study the effect of percentage replacement of natural sand by quarry dust & waste plastic (ldpe) in fabri form as 0%, 25%, 50%, 75%, and 100% respectively on the strength properties of concrete. The study was carried out on M20, M30, and M40 grade concrete with 0.5 water cement ratio. Waste plastic was mixed as 2, 4, 6, and 8% along with quarry dust to make full combinations. Regression analysis was done to co-relate the results of compressive strength for 7, 14, 28, 90 days represented in figure 8. An attempt was done to develop a model predicting the progressive compressive strength 7, 14, 28 & 90 days. Figure 9 represents the validation of models developed as in figure 8. Waste plastics have been incorporated with a view to enhance mechanical properties of concrete. Powders of micro fines as well as of ldpe were analyzed using the x-ray diffract meter. Scanning electron microscope (SEM) imaging was performed on specially prepared micro fine samples. Using SEM enabled the micro fines to be seen at higher resolution than possible with an optical microscope. This article reports the effects of dust content and the addition of a ldpe on mechanical properties.

## 3. MATERIALS

### Cement

Portland Pozzolana cement conforming to IS 1489 (part 1) -1991 was used. The physical properties are tabulated in Table 1.

**Table 1** Physical properties of Portland Pozzolana cement

| Property | Portland cement | IS:1489-1991 |
|---|---|---|
| Specific gravity | 3.10 | 3.10 - 3.14 |
| Fineness, m2/kg | 321 | ≥300 |
| Soundness, mm | 1.5 | < 10 |
| Normal consistency, % | 30.50 | ---- |
| Initial setting time, min | 164 | ≥30 |
| Final setting time, min | 224 | ≤ 600 |

### Fine Aggregate

Natural sand obtained from the river and normally available in the market was used. The quarry dust obtained from a local crusher was used. The physical properties of the natural and quarry dust are compared in Table. 2.

### Quarry rock dust

The Quarry Rock Dust obtained from local resource Siddheswar's Crushers (P) Ltd., Umred road, Nagpur was used in concrete to cast test cubes, beams and cylinder. The physical and chemical properties of Quarry Rock Dust obtained by testing the samples as per Indian Standards are listed in Tables 2 and 3, respectively.

**Table 2** Physical properties of quarry rock dust and natural sand

| Property | Quarry rock dust | Natural sand | Test method |
|---|---|---|---|
| Specific gravity | 2.54-2.60 | 2.6 | IS 2386 (Part III) 1963 |
| Bulk relative density (kg/m3) | 1720-1810 | 1460 | IS 2386 (Part III) 1963 |
| Absorption (%) | 1.20-1.50 | Nil | IS 2386 (Part III) 1963 |
| Moisture content (%) | Nil | 1.5 | IS 2386 (Part III) 1963 |
| Fine particles less than .075mm % | 15-Dec | 6 | IS 2386 (Part I) 1963 |
| Sieve analysis | Zone II | Zone II | IS 383-1970 |

**Table 3** Typical chemical composition of quarry rock dust and natural sand

| Constituent | Quarry rock dust (%) | Natural sand (%) | Test method |
|---|---|---|---|
| $SiO_2$ | 62.48 | 80.78 | IS: 4032-1968 |
| $Al_2O_3$ | 18.72 | 10.52 | |
| $Fe_2O_3$ | 06.54 | 01.75 | |
| CaO | 04.83 | 03.21 | |
| MgO | 02.56 | 00.77 | |
| $Na_2O$ | Nil | 01.37 | |
| $K_2O$ | 03.18 | 01.23 | |
| $TiO_2$ | 01.21 | Nil | |
| Loss of ignition | 00.48 | 00.37 | |

## Waste Plastic

Waste plastic represents the discarded Low Density Polyethylene (LDPE) as post consumer plastic waste in concrete collected from CHEMECH plastic manufacturing plant located in the MIDC area of Hingna road, Nagpur having the properties as in table 4.

**Table 4** Physical and mechanical properties of waste plastic

| Properties | Values |
|---|---|
| Density (g/cc) | 0.910-0.980 |
| Particle size | 5.00-50.0μm |
| Water absorption | 0.0100% |
| Max. moisture content | 0.100 |
| Tensile strength | 2.80-56.5Mpa |
| Modulus of elasticity | 0.11-0.449Gpa |
| Flexure modulus | 0.0248-1.38Gpa |

## Coarse aggregate

Natural aggregate having density of 1620 kg/m3 and fineness modules (FM) of 7.57 was used. The specific gravity was found to be 2.60 and water absorption as 1.32%.

### Admixture

Commercially available Super-plasticizer has been used to enhance the workability of fresh concrete for selected proportions of ingredients, an optimum dosage not exceeding 1% by weight of the cement.

## 4. CHARACTERIZATION OF MATERIALS:

### X-RAY DIFFRACTION

In x-ray diffraction, (ICAR 107-1 2006) x-rays are scattered by atoms in a pattern that indicates lattice spacing's of elements present in the material being analyzed. When the x-rays are in phase, they will give constructive interference and produce a wavelength peak in the x-ray diffraction pattern. By measuring the x-ray wavelengths over a wide range of angles, the inter planar spacing's of the material can be found. In order to identify an unknown substance, the powder diffraction pattern is recorded with the help of a diffract meter and a list of inter planar spacing and the relative intensities of the diffraction lines are prepared. This process can lead to a qualitative determination of the elements and compounds present in the substance analyzed. The results from x-ray diffraction show that a number of minerals are present in the micro fines. Each micro fine was analyzed to match the peak intensities found for the individual angles to those for known minerals in a database. A graph of one typical analysis is shown in Figure1, 2 where the micro fine peak intensity data is shown on the top graph and the known data is shown on the bottom whereas table.5 lists the minerals that matched x-ray intensities for each of the micro fines.

**Table 5** Lists of minerals that matched x-ray intensities for each of the micro fines.

| X-ray Diffraction Analysis | Mineral(s) |
|---|---|
| NS01 | Quartz($SiO_2$) , Manganese Bromide – ($MnBr_2$) |
| QS01 | Calcite-($CaCO_3$),Sodium–(Na) Nickel Vanadium Zirconium – Ni3VZr2 |

### SCANNING ELECTRON MICROSCOPY (SEM):

Scanning electron microscopy (SEM), (ICAR 107-1 2006) imaging was used to take pictures of the micro fines magnified at several levels. Figures 1,2,3 are images of different micro fines taken at 100x, 500x, and 1000x magnification and figure 4 is SEM micrograph of tensile fracture surface of LDPE. Each magnification serves a different purpose. The image taken at 100 x magnifications is intended to determine whether there are a sufficient number of particles in the SEM sample and whether they are adequately separated from one another by the epoxy matrix. The image taken at 500x magnification was used in the image analysis programs to quantify characteristics such as form, angularity, and texture for the different micro fines. Table 6 presents both the average factors calculated for each micro fine as well as the range of each factor.

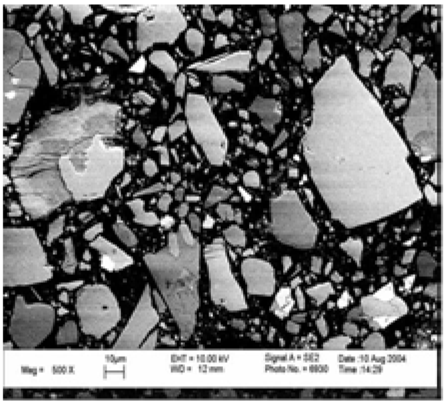


**Figure 1** SEM image for NS01

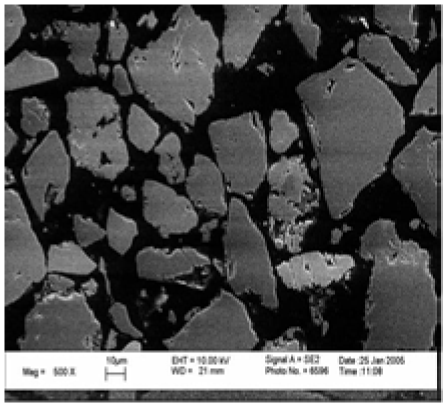


**Figure 2** SEM image (A) for QS01

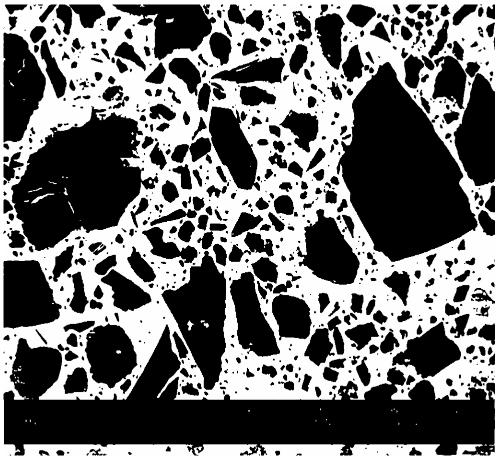


**Figure 3** Threshold image (b) of QS01

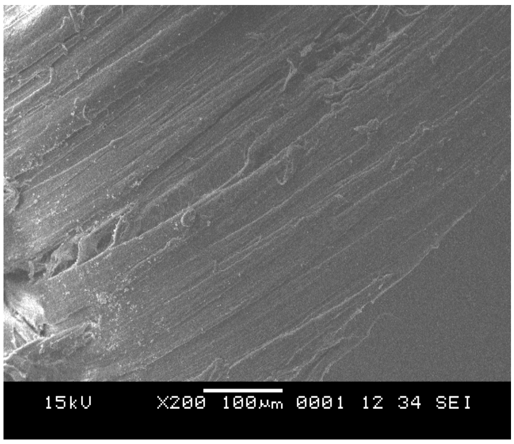



**Figure 4** SEM micrograph of tensile fracture surface of LDPE

**Table 6** The average factors for each micro fine as well as the range of each factor

| Sample | Elongation | Roundness | Diameter | Compactness | Angularity | Aspect Ratio |
|---|---|---|---|---|---|---|
| NS01 | 1.86 | 0.51 | 52.1 | 0.72 | 7.27 | 1.71 |
| | 1.00-1.69 | 0.11-0.91 | 8.7-247.7 | 0.34-0.96 | 4.04-16.33 | 1.10-2.83 |
| QS01 | 1.95 | 0.66 | 24.4 | 0.74 | 8.55 | 2.3 |
| | 1.05-9.24 | 0.20-1.10 | 7.9-272.5 | 0.37-1.01 | 3.66-18.58 | 1.1405.19 |

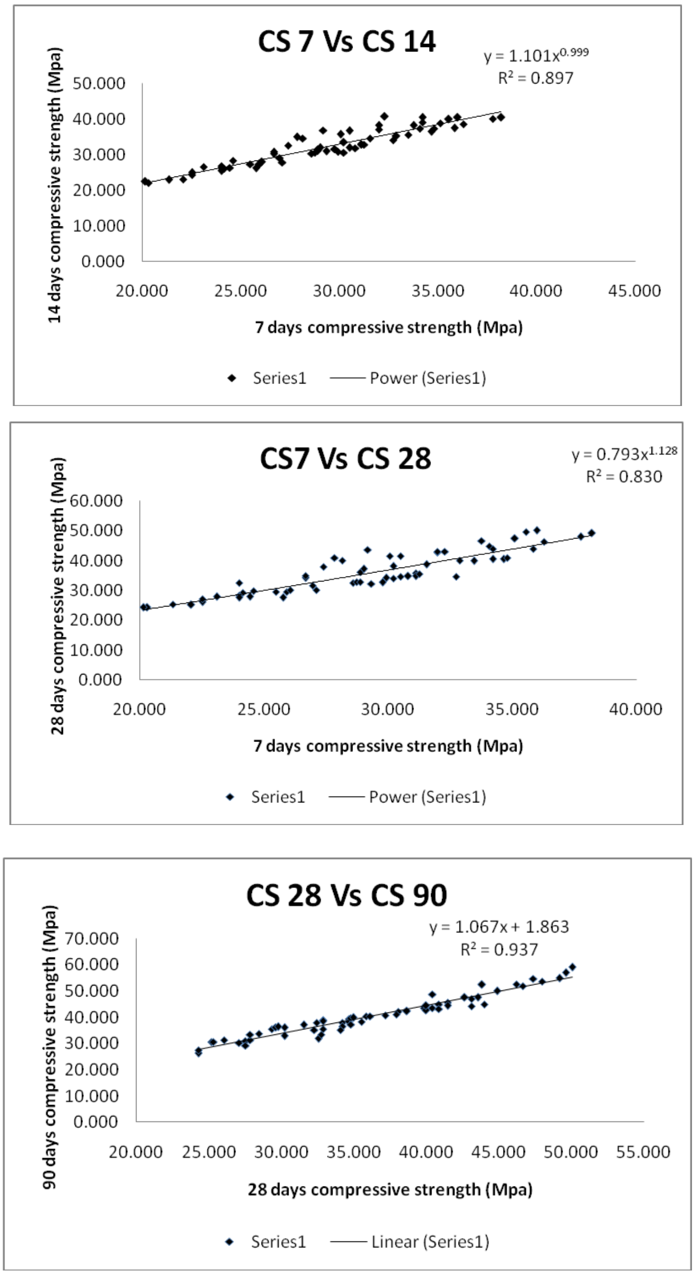
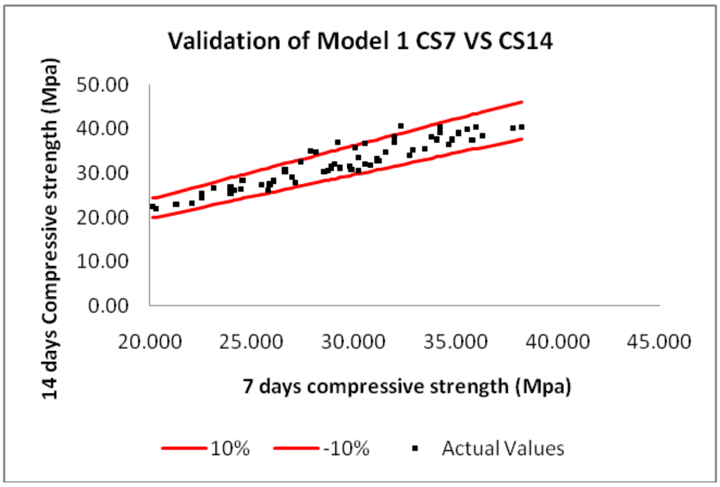
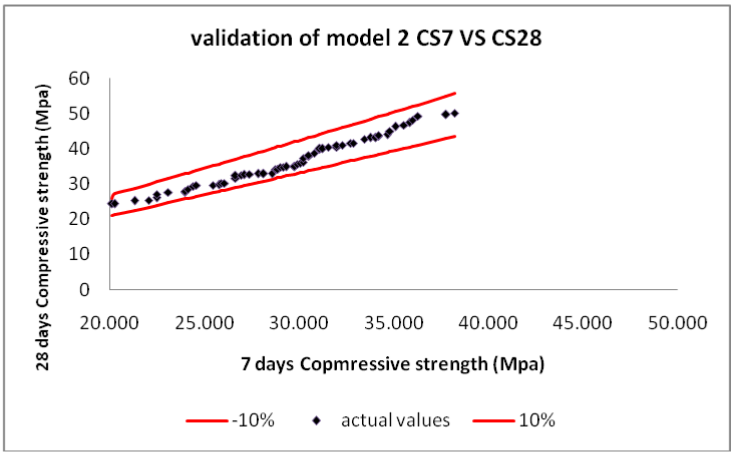



**Figure 5** Co-relation between 7days vs. 14 days compressive strength, Co-relation between 7day vs. 28 days compressive strength, Co-relation between 28days vs. 90 days compressive strength



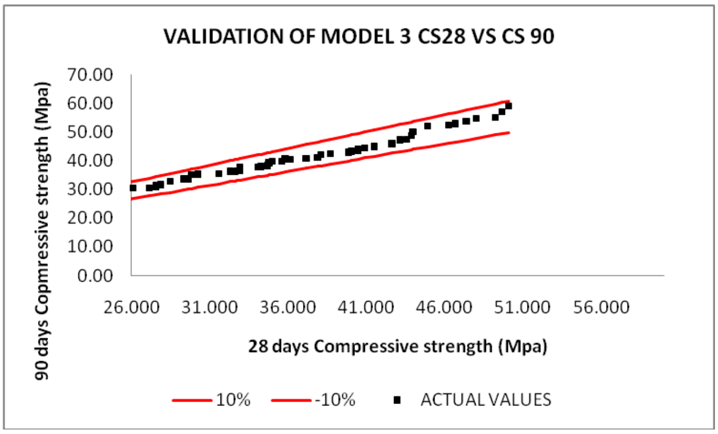




**Figure 6** Representing the validation of the respective models for 7days vs. 14, 7days vs. 28, 28 days vs. 90 days compressive strength.

## 5. CONCLUSION

1. It is understood from the particle size analysis that the fineness of quarry dust led to the improved pore structure properties leading to matrix densification properties. This is seen from the digital microscopy studies that the porosity of conventional concrete mixes were more and resulted in matrix cracking whereas a refined matrix densification is achieved with the quarry dust-waste plastic substitution.
2. The SEM images of natural sand shows that the surface is rough with presence of micro voids, whereas quarry dust particles are fine in nature with average size of 2 to 3micron. The images for ldpe shows that it is having lamellar, crystalline (fiber like) structure. It is not having porous structure. Due to lamellar structure, it increases the strength carrying capacity.

3. From regression analysis and development of mathematical models considering 7,14,28,90 days compressive strength it is well concluded that there exist a relationship that can very well predict the compressive strength for the progressive days and the results lies within plus –minus 10 % of predicted values.
4. From the above study it is also concluded that the waste plastic (ldpe) used plays a significant role in enhancing the strength.
5. It can be concluded from the test results that the addition of alternative fine aggregate material such as quarry dust along with waste plastic in concrete can be a potential application for mass concreting works in order to reduce the river sand depletion.
6. Further it can be concluded that the utilization of dust along with waste plastics leads to ecofriendly and economic construction.

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